Multimodal data representation and information fusion algorithms

We developed a dependency based multimodal data representation using R-Vine Copula for fusion.

Project ID : 630

Team Composition

		
Yogya Chukkapalli PES1201701144	Apeksha Gaonkar PES1201701562	P Jahnavi Raman PES1201701152

Guide: Dr. Sanjeev G.

Problem statement

To develop multimodal data representation and optimal information fusion algorithms.

Solution

We developed a dependency based multimodal data representation using R-Vine Copula for fusion.

Objective

Motivation:

- Usage of multiple sensors to acquire information about same event in order to gain new perspectives has been of interest in the recent years due to the development in both sensor technologies and IoT.
- But the high dimensionality of data poses problem in transmitting the data, storing the data and analysing it.

Solution:

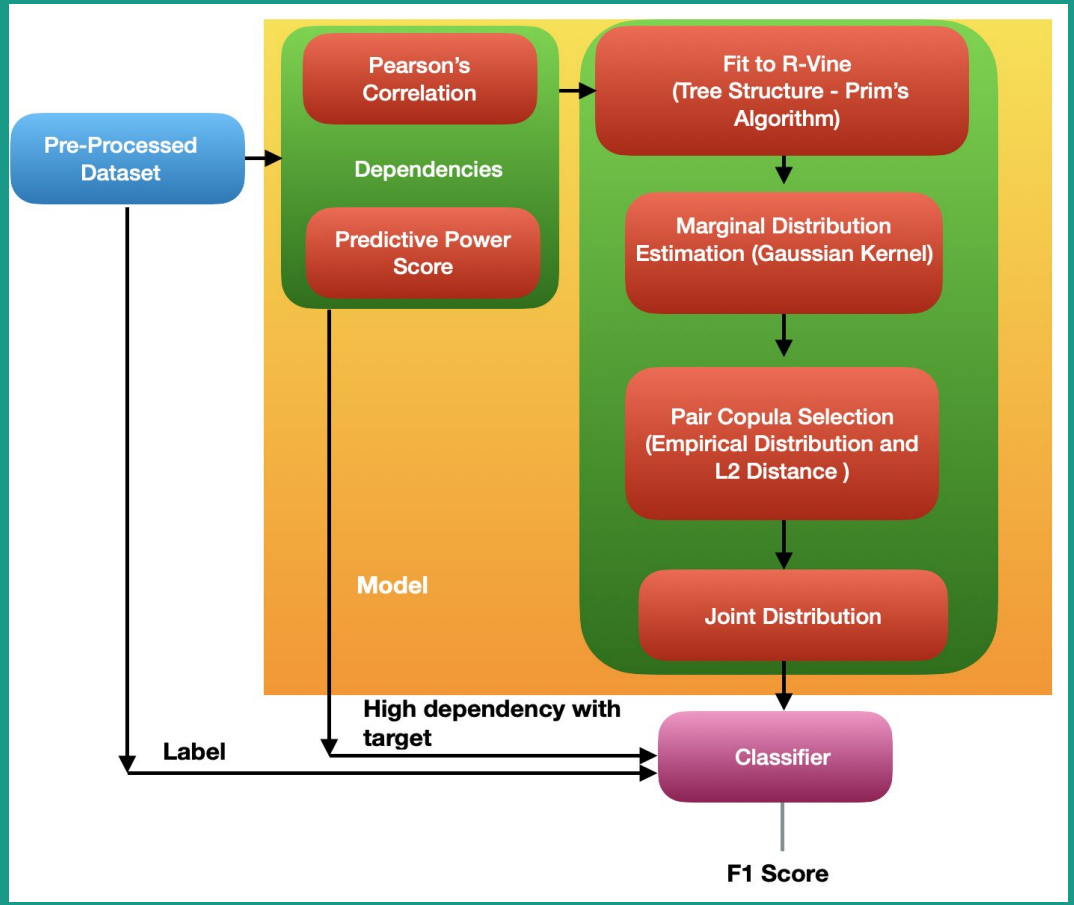
- We focus on developing a state of art model for multimodal data representation using copula theory which can not only represent the mutual information among fused features but also the characteristics specific to that feature.
- We also addressed the problem of feature selection while constructing a copula fusion model to achieve the balance of computation efforts and classification performance.

Base Paper

[1] S. Zhang, L. N. Theagarajan, S. Choi and P. K. Varshney, "Fusion of Correlated Decisions Using Regular Vine Copulas," in IEEE Transactions on Signal Processing, vol. 67, no. 8, pp. 2066-2079, 15 April, 2019, doi: 10.1109/TSP.2019.2901379.

- They have a distributed network of sensors to observe the phenomenon of interest and then transmit a compressed version of its data to the fusion center (FC).
- At FC they used **regular vine copula** based approach to approximate the joint PDF of sensor observations.
- As the data collected at the sensors is noisy, there is a threshold value set for each sensor such that only the values above this threshold are sent to FC. They used Neyman-Pearson formulation to get the threshold value.

Block Diagram



Datasets

STISEN:

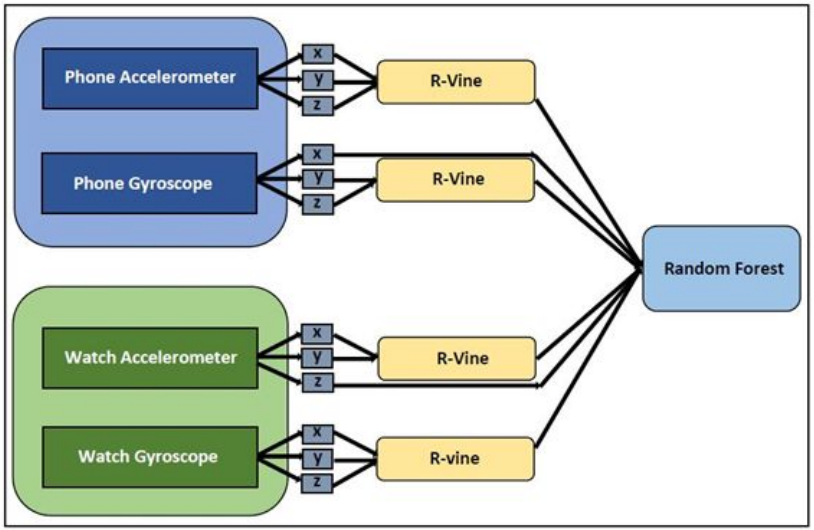
Human Activity Recognition dataset collected from Accelerometer and Gyroscope sensors from both Phone and Watch. The sensors generate 3 dimensional data with x,y and z values.In total there are 6 activities(Walk, Bike, Stand, Sit , Stairs up, Stairs down).

TMD:

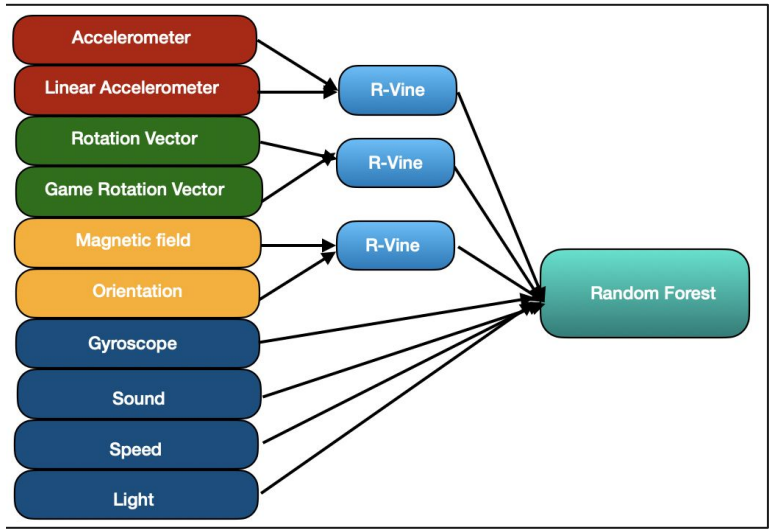
Transport Mode Detection dataset collected using 10 different sensors present in smart phone for about 5 seconds for each mode of transport. This time series data is plotted and it's mean is obtained. There are 5 modes of transport(Bus, Car, Still, Walk,Train).

Architectures

STISEN:



TMD:



Results

STISEN:

Model	F1
First level fusion	98.50
Second level fusion of phone gyroscope and watch gyroscope	97.56

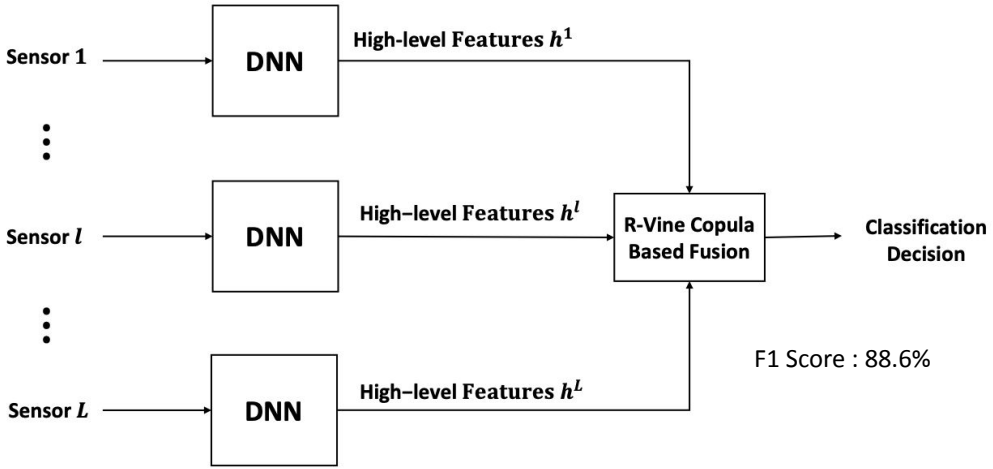
TMD:

Model	F1
Fuse [Acc, Linear Acc and Gyr] [Rotation and Game rotation][Magnetic field and orientation]	98.484
Fuse [Acc, Linear Acc] [Rotation and Game rotation][Magnetic field and orientation]	98.569
Fuse [Acc, Linear Acc] [Rotation and Game rotation]	98.643

Discussion

STISEN:

[2] S. Zhang, B. Geng, P. K. Varshney and M. Rangaswamy, "Fusion of Deep Neural Networks for Activity Recognition: A Regular Vine Copula Based Approach," 2019 22th International Conference on Information Fusion (FUSION), Ottawa, ON, Canada, 2019, pp. 1-7

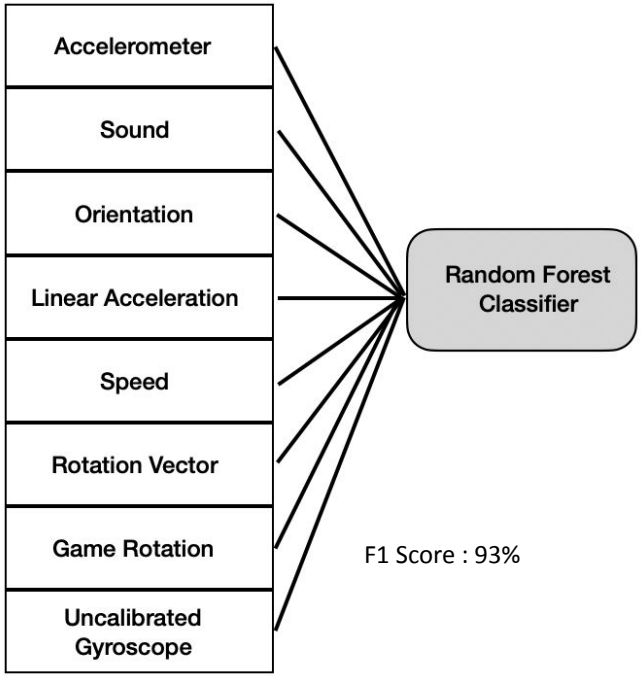


F1 Score : 88.6%

Discussion

TMD:

[3] C. Carpineti, V. Lomonaco, L. Bedogni, M. D. Felice and L. Bononi, "Custom Dual Transportation Mode Detection By Smartphone Devices Exploiting Sensor Diversity," 2018 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), 2018, pp. 367-372, doi: 10.1109/PERCOMW.2018.8480119.



Discussion

Observations:

1. Various researches have shown that copula-based fusion of multiple sensing observations can significantly improve the performance of interference problems which is again seen in this work.

2. Feature selection plays a vital role in increasing the performance of the model

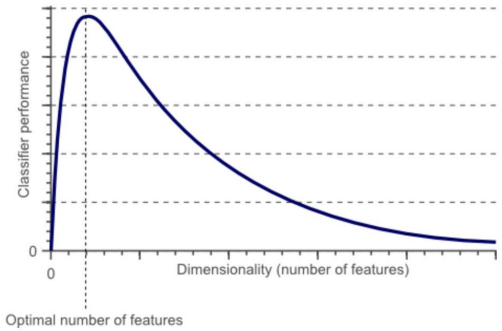
Discussion

Observations:

1. Various researches have shown that copula-based fusion of multiple sensing observations can significantly improve the performance of interference problems which is again seen in this work.

2. Feature selection plays a vital role in increasing the performance of the model.

3. Fusing Non-Dependent features for reducing dimension can decrease the accuracy. But the rate of decrease in accuracy is low.



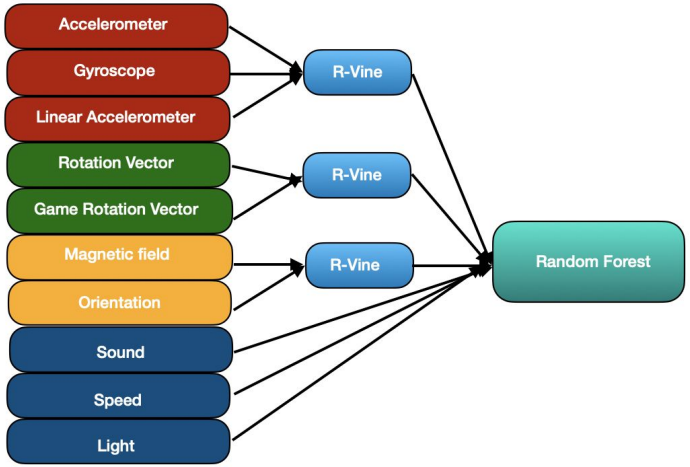
Discussion

Findings:

Various structures have been experimented with to find the threshold value(+-0.5 : corr) for Fusion of features.

We wish that this (Finding the threshold for a given dataset) can be automated in future using statistical techniques.

Example,



Thank You